MASTER

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The Climatic Aspects of Horticulture in the South West Region

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This memorandum was prepared as part of a Report on the Potential Horticultural Areas in the South West Region, i.e. over the counties of Gloucestershire, Wiltshire, Dorset, Somerset, Devonshire and Cornwall (including the Isles of Scilly). It is directed to those interested in horticulture rather than to meteorologists. The object of the full Report was to assess areas which appear to be of potential horitoultural value and any allusion to grades in the text refers to this assessment.

The marked climatic differences which occur within the South-west Region do much to determine the value of horticultural land. In broad terms, the western parts of the region have a more maritime climate than the north-east, with high winter temperatures and a long growing season. They are, therefore, favourable for early production where soils are suitable and rainfall and exposure are not excessive. To the north and east, wind is seldom a problem but the growing season is shorter and there is a considerable risk of spring frosts, so that maincrop production is more suitable. In the drier parts of the region, irrigation is needed for a wide range of crops, including tree fruit. There is a wide diversity of relief and the effects of local topography, aspect and shelter add variety to the general pattern, giving land better suited to later production in the early areas and vice versa.

Temperature

Earliness is largely the result of favourable temperature, particularly in late winter and early spring. The following table summarizes temperature over the region. Values for Worthing are also given so that comparison may be made with South-east England.

Monthly averages of maximum, minimum and mean temperatures (°F.), 1926-50

	Penzance 55 ft.			Weymouth 16 ft.			Cheltenham 214 ft.			Worthing 25 ft.		
	Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.	Mean
Jan.	49.6	41.3	45.5	47.5	37.9	42.7	44.7	34.8	39.7	45.2	36.7	40.9
Feb.	49.4	40.7	45.1	47.2	37.8	42.5	45.5	34.6	40.1	45.3	36.4	40.9
Mar.	52.0	41.9	47.0	50.7	38.9	44.8	50.8	36.2	43.5	49.3	38.2	43.8
Apr.	55.2	44.0	49.6	55.3	42.0	48.6	55.8	39.7	47.7	54.0	42.0	48.0
May	60.0	47.8	53.9	60.7	46.7	53.7	62.5	44.6	53.5	59.8	47.2	53.5
June	65.0	52.5	58.8	65.8	52.4	59.1	68.3	50.3	59.3	65.5	52.8	59.1
July	67.3	55.6	61.5	68.4	56.0	62.2	70.9	54.2	62.6	68.3	56.6	62.5
Aug.	67.7	55.8	61.7	68.9	56.2	62.6	70.4	53.6	62.0	68.7	56.6	62.6
Sept.	64.7	53.6	59.1	65.8	53.1	59.5	65.4	49.9	57.6	65.4	53.4	59.4
Oct.	59.2	49.2	54.2	59.5	48.0	53.8	57.3	43.8	50.6	58.3	47.5	52.9
Nov.	53.9	44.7	49.3	52.6	42.3	47.4	49.3	38.4	43.9	50.9	41.5	46.2
Dec.	50.5	41.9	46.2	48.3	38.8	43.5	45.1	35.6	40.4	46.2	37.5	41.8
Year	57.9	47.4	52.7	57.6	45.9	51.7	57.2	43.0	50.1	56.4	45.5	51.0

Temperatures in the Isles of Scilly are very similar to those at Penzance, but winters are slightly warmer and summers somewhat cooler than on the mainland.

The average maximum and minimum temperatures for Penzance, Cheltenham and Worthing are shown in Fig. 1. There are marked temperature differences between Penzance and Cheltenham. Nights are warmer at Penzance than at Cheltenham throughout the year and in autumn, winter and spring the differences in average minimum temperature range from 4° to 6°F. Day temperatures are higher at Penzance from October to March inclusive with a maximum difference of some 5°F. in mid-winter. During the winter months (December to February) the average temperature for the whole day is some $5\frac{1}{2}$°F. higher in Cornwall than in North Gloucestershire. This is about the same as the difference between West Cornwall and North-west Scotland, at sea-level.

West Cornwall also shows an advantage over South-east England, where Worthing temperatures are intermediate between those for Penzance and Cheltenham in many months of the year. In the spring months of March, April and May, however, the day temperatures at Worthing are lower than those for Penzance and Cheltenham.

A frost is said to occur when the air temperature at a height of about 4 feet above ground level falls to freezing point, irrespective of whether or not there are any visibile signs of frost. In general, frosts are less likely close to the sea because of the heat capacity of water and also because there is usually more air movement near the coast than inland. Site factors have a great influence on the incidence of frost and generalization is therefore hazardous. The following remarks apply only to sites with good air drainage and differences of a month or more may be expected in frosty sites. In South-western coastal districts, the first frosts of the autumn occur on average around the middle of December; moving east they become earlier and occur about the middle of November along the Dorset coast; further north, in Gloucestershire, the average date is in the second half of October.

In the early areas along the coast in the South-west the last spring frosts occur on average in the first half of March; along the Dorset coast they occur in late March and in all inland districts usually in late April, though in some places they are delayed until May.

The average and extreme dates of first and last frosts are given below, with Worthing and Tunbridge Wells for comparison.

Average and extreme dates of first and last frosts

		First frost		Last frost	
Place	Period	Average	Extreme	Average	Extreme
Penzance (Gulval)	1924-58	14/12	22/10	15/3	23/4
Weymouth	1911-58	17/11	15/10	27/3	1/5
Cannington	1928-58	28/10	22/9	18/4	17/5
Cheltenham	1912-53 (incomplete)	27/10	1/10	21/4	27/5
Shaftesbury	1912-58	7/11	3/10	21/4	22/5
Worthing	1912-58	15/11	20/9	2/4	17/5
Tunbridge Wells	1912-58 (incomplete)	18/10	19/9	28/4	22/5

When using this table, three points need to be borne in mind. The first is that Penzance sometimes has a winter without frost so that the data in the table refers to those years when frost occurred; there are so many frost-free years in the Isles of Scilly that mean dates have not been computed. The second is that the extreme dates become more extreme as the period of observation is increased. The third is that the data refer to reasonably well-exposed sites; there are certainly some areas where poor air drainage will result in a shorter frost-free period. On the other hand, individual fields on middle slopes with a southerly aspect will have a longer frost-free period. The variability of frost incidence is illustrated by the data from Ilfracombe and Barnstaple, only 10 miles apart as the crow flies. At Ilfracombe, the average data of the last frost is February 25th, which is earlier than any other place in the region for which there are records. At Barnstaple, the average date is April 22nd. Similar differences occur for the first frost in autumn, with average dates of October 25th for Barnstaple and December 18th for Ilfracombe. The frost-free period at Ilfracombe is therefore 295 days, but it is only 185 days at Banstaple. No doubt such gross differences are mainly due to differences of site, but the figures emphasize the dangers of generalization when discussing frost.

Not only is frost less frequent in the south-west of the region than in the north but it is also less severe. February 1956 was one of the coldest months of the present century. During this month the minimum temperature recorded on Scilly was 27°F; at Penzance it was 20°F. and over much of Cornwall it was 15-20°F; further north it was much lower and fell to 7°F. near Bristol.

Growth of native plants and many outdoor crops becomes appreciable in this country when the mean daily trmperature exceeds about 42°F. (assuming that there are no other limiting factors such as water or light). Almost everywhere along the coasts of the region the mean temperature throughout the year is 42°F. or more and only short checks to growth are likely - in many years, growth will be more or less continuous, particularly in the West. From the Exe westwards, many inland areas will also have growth throughout many winters, provided they are not more than a few hundred feet above sea level. This is not entirely an unmixed blessing, as weeds also continue their growth for much, if not all, of the winter. In North Gloucestershire, the average period when there is no growth in the open lasts from about the end of November to early March.

The earliness of the South-west is also brought out by the following table which contains the accumulated number of degree-days above 42°F. The values in this table take account of the amount by which the temperature exceeds 42°F and also of the period during which it is above 42°F. For example, a temperature of 52°F. for 1 day counts as 10 degree-days, as do also temperatures of 47°F. for 2 days or 43°F. for 10 days.

	Scilly	Penzance	Weymouth	Cheltenham	Worthing
Jan.	156	112	53	21	25
Feb.	128	95	44	25	23
Mar.	163	154	111	91	84
Apr.	210	228	198	190	180
May	332	369	363	357	357
June	462	504	513	519	513
July	573	605	626	639	635
Aug.	595	611	639	620	639
Sept.	510	513	525	468	522
Oct.	391	378	366	267	338
Nov.	240	219	162	83	130
Dec.	175	131	73	24	33
Year	3935	3919	3673	3304	3479

The totals for the winter half-year (October-March inclusive) are of most interest for earliness. At Scilly the total is 1253, which is 32% of the annual total, at Penzance 1089 (28%), at Weymouth 809 (22%) at Cheltenham 511 (15%), and at Worthing 633 (19%).

The accumulated number of degree-days below 60°F. can be used to indicate heating requirements in glasshouse districts, assuming that the inside temperature is not allowed to fall below 60°F.

Values are given below for a selection of places:-

	Penzance	Weymouth	Cheltenham	Littlehampton
Jan.	449	536	629	601
Feb.	421	494	562	545
Mar.	403	471	511	515
Apr.	312	342	369	372
May	189	198	205	214
June	69	66	63	75
July	43	31	43	34
Aug.	43	28	25	47
Sept.	75	66	105	87
Oct.	183	201	291	233
Nov.	321	378	483	429
Dec.	428	511	608	570
Year	2936	3322	3894	3722

The numbers of degree-days below 60°F. for the period of heating for individual crops are as follows:-

	Penzance	Weymouth	Cheltenham	Littlehampton
Tomatoes	2450	2870	3305	3455
Cucumbers	2765	3185	3665	3315
Lettuce	2165	2575	2975	2855
Carnations	2230	2660	3080	2975
Chrysanthemums	1695	2020	2345	2250

The above figures are based on the following dates for heating; tomatoes November 4th to May 28th; cucumbers October 4th to July 4th; lettuce November 11th to April 27th; carnations November 4th to April 27th; chrysanthemums November 27th to March 28th. Roughly, 10 degree-days can be taken as equivalent to 1 ton of coal per acre of glass, so that 40-45 tons more coal are needed to produce an acre of tomatoes in North Gloucestershire than along the Dorset coast.

Earth Temperature

The following table gives computed long period averages of earth temperature at a depth of 1 foot.

Monthly averages of earth temperature at 1 ft. depth, (°F.)

Station	Falmouth	Plymouth	Ilfracombe	Cullompton	Holton Heath	Bristol	Cheltenham
Altitude (ft.)	167	117	25	202	64	206	214
Soil	Light sandy	Loam	Loam over clay	Light sandy gravel drift	Sand above gravel	Clay loam	Light loam over sand
Jan.	44.2	43.0	43.4	41.9	40.6	41.0	39.8
Feb.	44.2	42.7	43.1	41.9	40.8	40.8	39.6
Mar.	46.4	44.8	45.3	44.3	43.5	42.9	42.4
Apr.	51.2	49.9	50.3	49.7	49.0	48.5	48.4
May	56.5	55.5	55.9	55.7	56.0	54.4	55.0
June	61.8	61.2	61.5	61.6	62.7	60.5	61.6
July	64.3	64.0	64.2	64.0	65.7	63.7	64.5
Aug.	64.2	63.5	63.9	63.2	65.1	63.5	63.9
Sept.	61.5	60.1	60.7	59.4	60.7	60.4	60.0
Oct.	55.9	54.2	55.0	52.9	54.4	54.4	52.7
Nov.	49.5	48.0	48.7	46.7	46.9	46.4	45.4
Dec.	45.6	44.3	44.8	43.0	42.2	43.8	41.0
Year	53.8	52.6	53.1	52.0	52.4	51.6	51.3

Differences in altitude and soil type make detailed analysis of earth temperatures difficult but the annual values show that over the year as a whole the earth at 1 foot is a degree or two warmer in the south-west of the region than in the north-east. The difference is most marked in winter and almost disappears in the summer; in the winter months (December, January and February) the earth temperature at Falmouth is some 4.5°F. above that at Cheltenham. This is no doubt of great significance in earliness, as Cornwall has larger reserves of heat than Gloucestershire; when the surface of the soil and the air in contact with it are cooled, there is conduction of heat from the warmer earth below which tends to overcome the effects of cooling.

Sunshine

Sunshine in the British Isles usually decreases with distance from the sea, with altitude and with latitude.

Monthly daily means for selected stations are given in the following table and values for Penzance, Torquay, Cheltenham and Worthing are shown graphically in Figure 1.

Monthly Means of Bright Sunshine (hours/day) 1921-50

	Scilly	Penzance	Torquay	Weymouth	Cheltenham	Worthing
Jan.	1.92	1.85	1.94	2.03	1.52	2.17
Feb.	2.77	2.74	2.74	2.83	2.38	2.93
Mar.	4.37	4.28	4.43	4.58	3.88	4.74
Apr.	6.21	5.98	6.00	6.01	5.06	6.05
May	7.24	6.74	6.92	7.09	5.88	7.49
June	7.63	7.39	7.83	7.79	6.59	8.11
July	6.53	6.38	6.84	6.90	5.67	7.49
Aug.	6.50	6.37	6.70	6.76	5.48	7.05
Sept.	5.20	5.09	5.26	5.18	4.37	5.64
Oct.	3.86	3.78	3.81	3.74	3.28	4.02
Nov.	2.57	2.49	2.45	2.42	1.82	2.54
Dec.	1.79	1.78	1.91	1.82	1.39	2.03
Year	4.72	4.58	4.74	4.77	3.95	5.03

In the Isles of Scilly, Cornwall and along the south coast of Devon and Dorset the mean duration of sunshine over the whole year is $4\frac{1}{2}$ to $4\frac{3}{4}$ hours per day, and it falls to about 4 hours per day in North Gloucestershire.

Between 30 and 31% of the annual sunshine in these districts occurs in the winter half year (October-March). Expressed in total hours, this amounts to 510-530 in the south and 430-440 in the north, compared with some 560 hours in the Worthing district.

No light records are available, but there is undoubtedly some pollution from the Avonmouth-Bristol industrial areas. Districts to the north and east of Avonmouth and Bristol will be most subject to pollution. The extent of the area affected is uncertain but it is not likely to be great.

Wind

The South-west Region varies a good deal in respect of wind. In the Scillies the mean wind speed over the whole year exceeds 15 m.p.h.; in Cornwall and much of Devonshire it is 12.5 to 15 m.p.h., but inland it decreases to something under 10 m.p.h. in Gloucestershire and north Wiltshire. Correspondingly, the number of days with a gale (39 m.p.h. or more) decreases from about 30 in Scilly and the Lands End-Lizard district to 2 or less inland in the east and north. As would be expected, the coastal areas of Devon and Cornwall have considerably more gale days than places nearer the centre of the peninsula.

In many parts of the region, wind is undoubtedly a major hazard in growing, particularly in the South-west. The small fields and high hedges in Scilly are eloquent testimony to this. In addition to hedges, which may be difficult to establish in some places, two other factors can help to mitigate the effects of wind:-

(i) Geomorphic shelter, afforded by the dispostion and shape of the land. For example, sites in Cornwall some 80 to 100 feet below the plateau level of about 250 feet have an average wind speed some 15% less than sites on the plateau. This implies a reduction of about 40% in the energy of the wind, which will therefore be considerably less likely to cause physical damage, e.g., to glass or other structures.

(ii) Low artificial shelter such as lath fencing or hop lewing.

Detailed wind records from Scilly, The Lizard and Boscombe Down (on Salisbury Plain) show that south-west and west winds predominate in summer, autumn and winter. In spring, however, there is a greater risk of north-east and east winds, and The Lizard and Boscombe Down these directions predominate in spring. These winds constitute a serious hazard for early crops, particularly if a site has been selected to give protection from the prevailing south-westerlies.

The following table gives the percentage number of hours when the wind speed was Force 6 or more and Force 8 or more. Force 6 is a strong breeze which sets large branches in motion; whistling is heard in telegraph wires and umbrellas are used with difficulty. Force 8 is a fresh gale which is strong enough to break twigs off trees and generally to impede progress when walking.

Place	Force	Spring	Summer	Autumn	Winter
Scilly	6 or more	17.5	7.1	21.4	35.6
	8 or more	0.9	0.2	1.9	4.0
Lizard	6 or more	10.6	5.7	15.0	22.5
	8 or more	0.8	0.2	1.8	3.2
Boscombe Down	6 or more	1.2	0.8	2.2	5.2
	8 or more	0	0.1	0.1	0.1

The difference between a coastal site and an exposed inland site is very marked. This difference could of course, be much increased if a sheltered inland site were selected.

Rainfall

The average annual rainfall varies from 60-80 inches on the higher parts of Bodmin Moor, Dartmoor and Exmoor to some 26 inches in the Severn valley near Gloucester. The following table gives the average monthly rainfall (1916-50) for a number of places in or near areas of present or potential horticultural values.

Average monthly rainfall (inches), 1916-50

	Penzance	Plymouth	Exmouth	Taunton	Yeovil	Beaminster	Market Lavington	Cheltenham
Jan.	5.01	4.29	3.43	3.00	3.29	4.36	2.93	2.56
Feb.	3.50	3.08	2.39	2.10	2.32	3.02	2.10	1.93
Mar.	3.17	2.73	2.38	1.95	2.07	2.67	1.83	1.72
Apr.	2.51	2.20	2.16	1.94	2.07	2.49	2.10	2.00
May	2.44	2.37	2.25	2.24	2.38	2.61	2.18	2.11
June	1.96	2.00	1.74	1.67	1.77	1.97	1.80	1.80
July	2.74	2.57	2.27	2.23	2.70	3.04	2.55	2.42
Aug.	2.95	2.88	2.56	2.32	2.83	3.14	2.45	2.40
Sept.	3.15	2.89	2.62	2.44	2.73	3.21	2.51	2.30
Oct.	4.36	3.81	3.09	3.06	3.50	4.14	3.04	2.70
Nov.	4.90	4.46	3.57	3.26	3.70	4.84	3.10	2.82
Dec.	4.84	4.48	3.54	3.09	3.39	4.58	2.91	2.53
Year	41.53	37.76	32.00	29.30	32.75	40.07	29.50	27.29

The diagrams in Figure 3 show that in the south and west of the region the driest period of the year is normally from April to June, with 17-18% of the annual rainfall; the wettest period is from November to January with 33-35%. In the north and east it is normally driest from February to April (19-20%) and wettest from October to December (28-32%).

There is, of course, wide variation in the amount of rain which falls in any given month at one station, and the rainfall variation diagrams for the period 1916-50 (Figure 2) give an indication of this. In these diagrams the white dots represent the median rainfalls. The median is the value which has an even chance that the rainfall will occur above or below it: for example, the Cheltenham value for January is 2.5 inches and in any January the rainfall is equally likely to be above or below this amount. The black dots indicate the extreme rainfalls recorded during the period 1916-50 and the black areas show the central 50% of recorded rainfalls. Thus at Cheltenham there is an even chance that the January rainfall will lie between 1.6 and 3.3 inches. The black area is smallest when the rainfall is least variable and greatest when it is most variable. In general, rainfall is least variable in spring, particularly in April; it is most variable in autumn and winter, particularly in November.

The tendency for rather dry weather in spring and early summer may be an advantage to many horticultural crops in some years but in other years the water needs of the growing crops may considerably exceed the rainfall. The following water needs have been calculated for a period of 20 years, assuming that the soil moisture deficit should not be allowed to fall far below 1 inch for the general run of horticultural crops (see Figure 3). For bush and cane fruits, a larger soil moisture deficit could be allowed and the irrigation needs would not be so great.

Number of years in 20 when the irrigation needs exceed stated amounts

Irrigation needs (inches)	0	2	4	6
Penzance	19	15	8	3
Bude	20	17	15	6
Plymouth	19	16	12	5
Exmouth	20	18	15	7
Swanage	20	18	17	13
Yeovil	20	17	12	5
Cannington	20	18	16	5
Bromham	19	18	14	4
Long Ashton	19	18	7	3
Cheltenham	19	18	16	10

On the basis of these figures there is little doubt that irrigation would be a decided advantage for the maximum production of shallow-rooted crops. Even as far west as Penzance there is an irrigation need of 4 inches or more in 8 years out of 20. It is, of course, true that the need for irrigation would be felt rather less on the more retentive soils.

Humidity

Long periods of high relative humidity during warm weather are often associated with plant diseases, such as potato blight and apple scab. Relative humidity depends on both the amount of water vapour in the air and on the temperature, so that much care is needed in interpreting the data. The following table gives the average monthly relative humidity at 5 places in the region, based on readings at 0300, 0900, 1500 and 2100 G.M.T.

Monthly averages of relative humidity (per cent.)

	St. Mary's (Scilly)	Plymouth	Exeter	Boscombe Down	Lyneham
Period	1945-58	1945-58	1946-58	1945-58	1946-58
Jan.	83	86	86	91	91
Feb.	84	85	83	89	88
Mar.	87	83	82	84	83
Apr.	84	79	78	78	77
May	86	80	79	79	79
June	87	83	80	80	80
July	87	83	80	80	80
Aug.	87	85	82	83	83
Sept.	87	87	85	87	86
Oct.	86	87	86	88	87
Nov.	84	86	87	91	90
Dec.	84	87	87	92	91
Year	86	84	83	85	85

The annual values are very similar at all stations but a comparison of Plymouth with Exeter, Boscombe Down and Lyneham shows that the coast is the more humid during the summer months, which are of most importance in relation to disease. The hourly values show that the diurnal variation in the summer is considerably greater inland than on the coast or the islands, which implies that there is less chance of a spell of high humidity inland than along the coast.

The July values are given below as an example.

July averages of relative humidity at stated times (per cent)

Time G.M.T.	St. Mary's (Scilly)	Plymouth	Exeter	Boscombe Down	Lyneham
0300	93	92	92	94	93
0900	87	81	78	78	79
1500	79	75	66	64	65
2100	90	84	83	84	82
Range	14	17	26	30	28

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National Agricultural Advisory Service,
Bristol.

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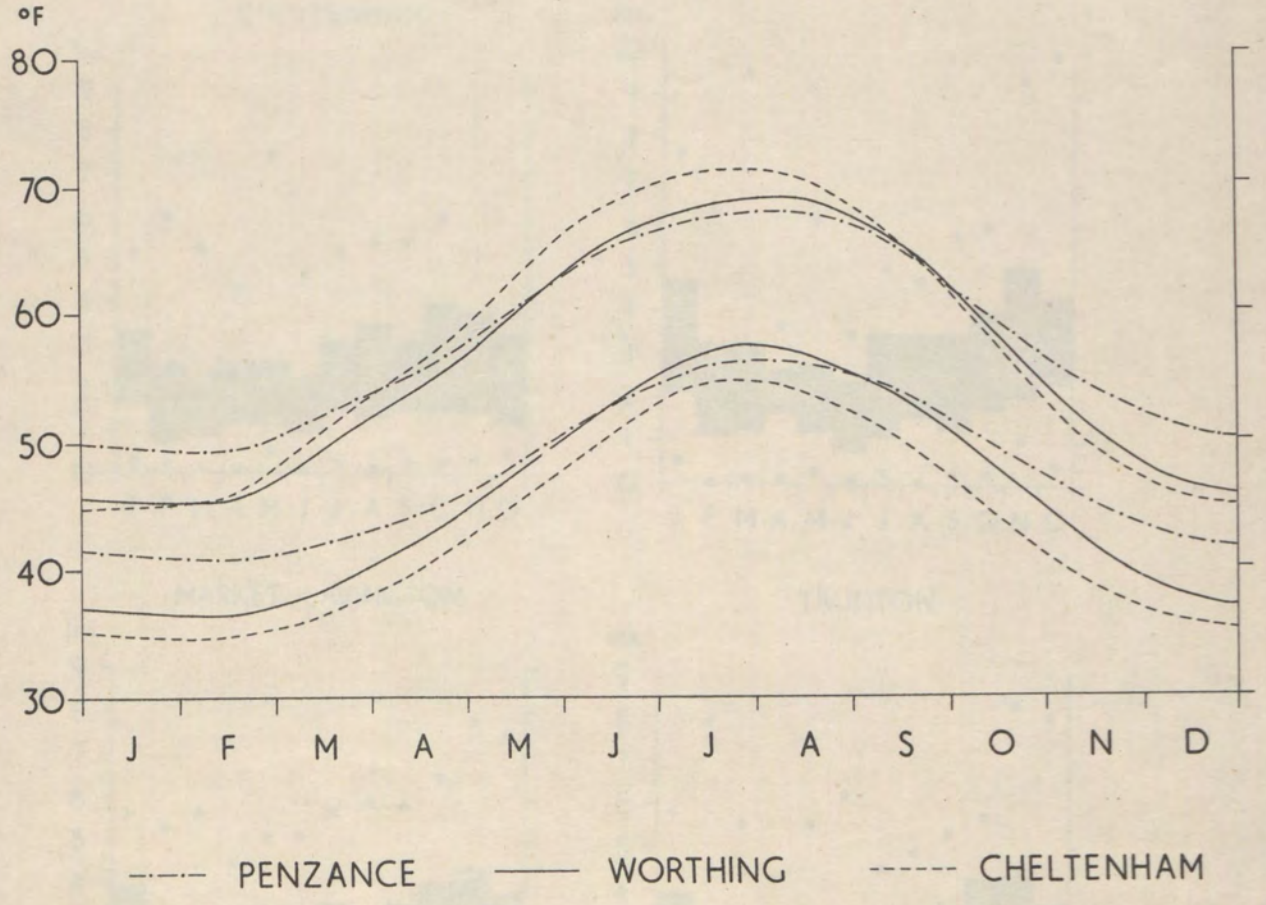
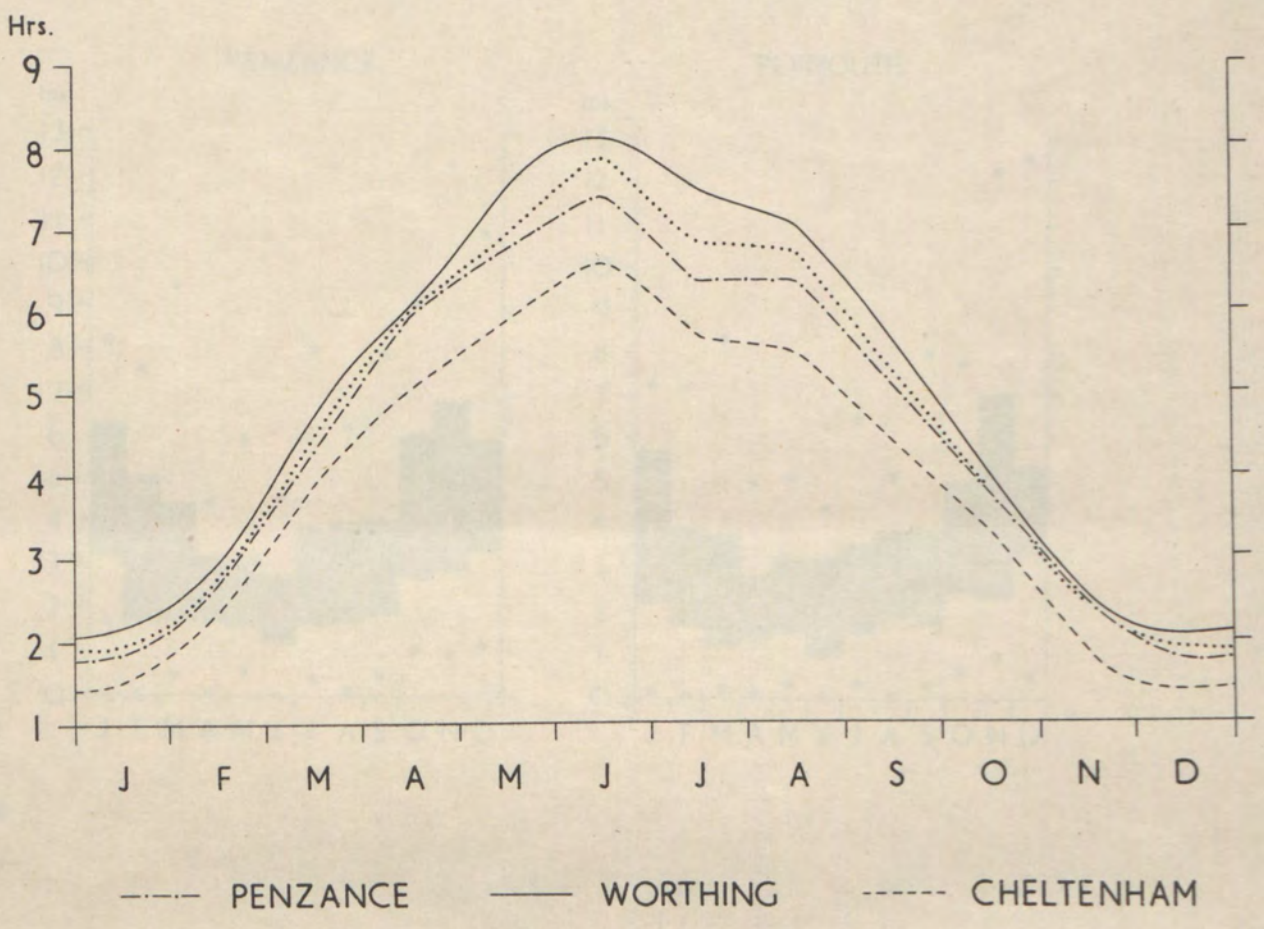
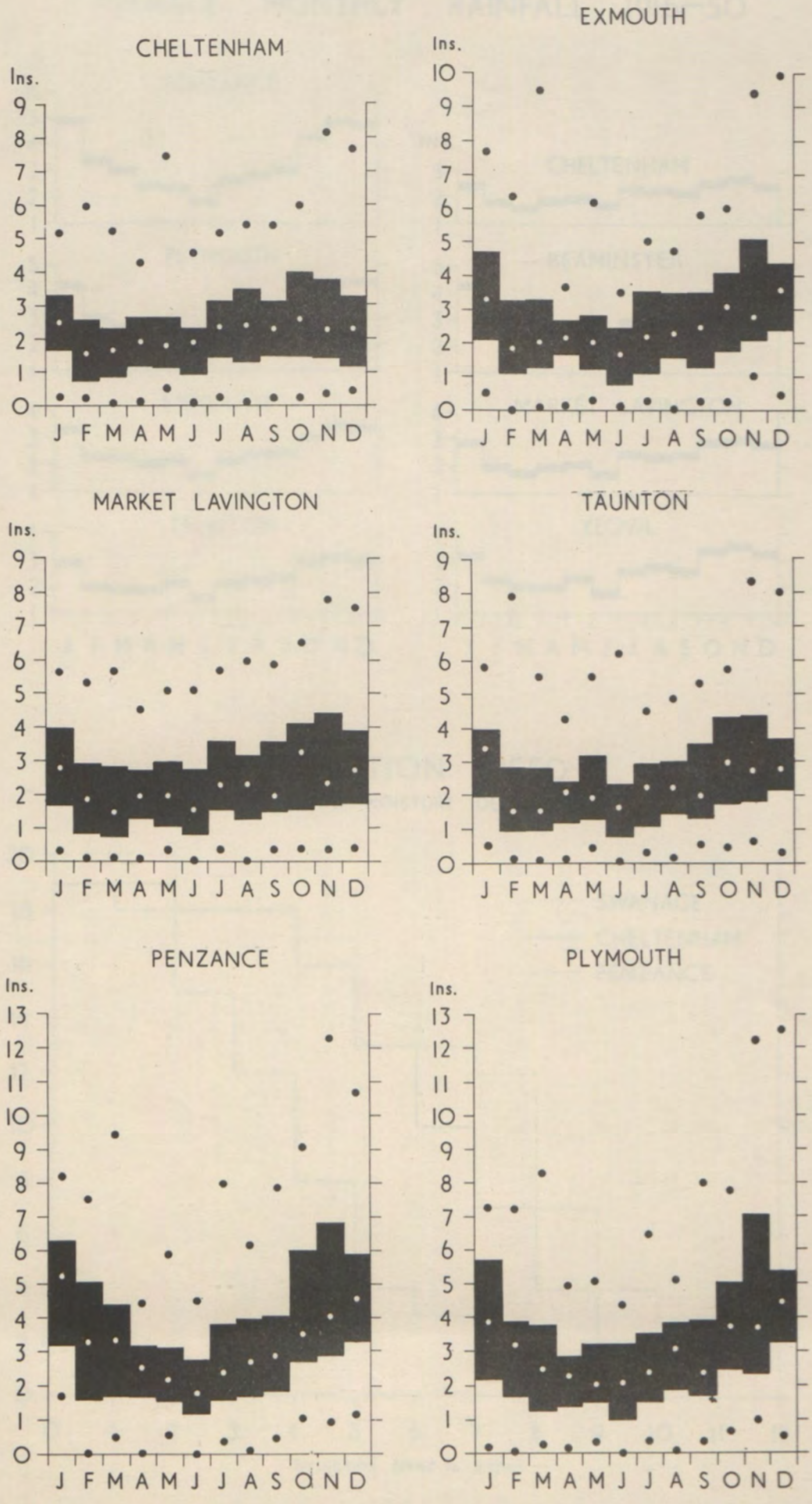
MONTHLY AVERAGES OF MAXIMUM & MINIMUM TEMPERATURES



AVERAGE HOURS OF SUNSHINE PER DAY



RAINFALL VARIATION DIAGRAMS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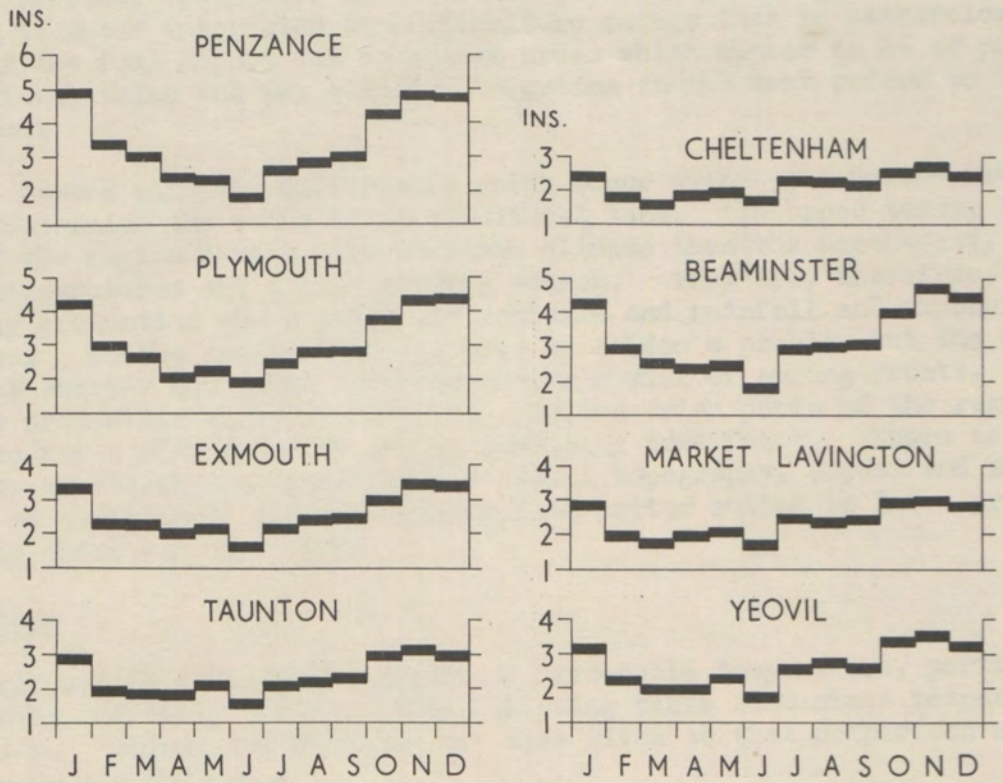
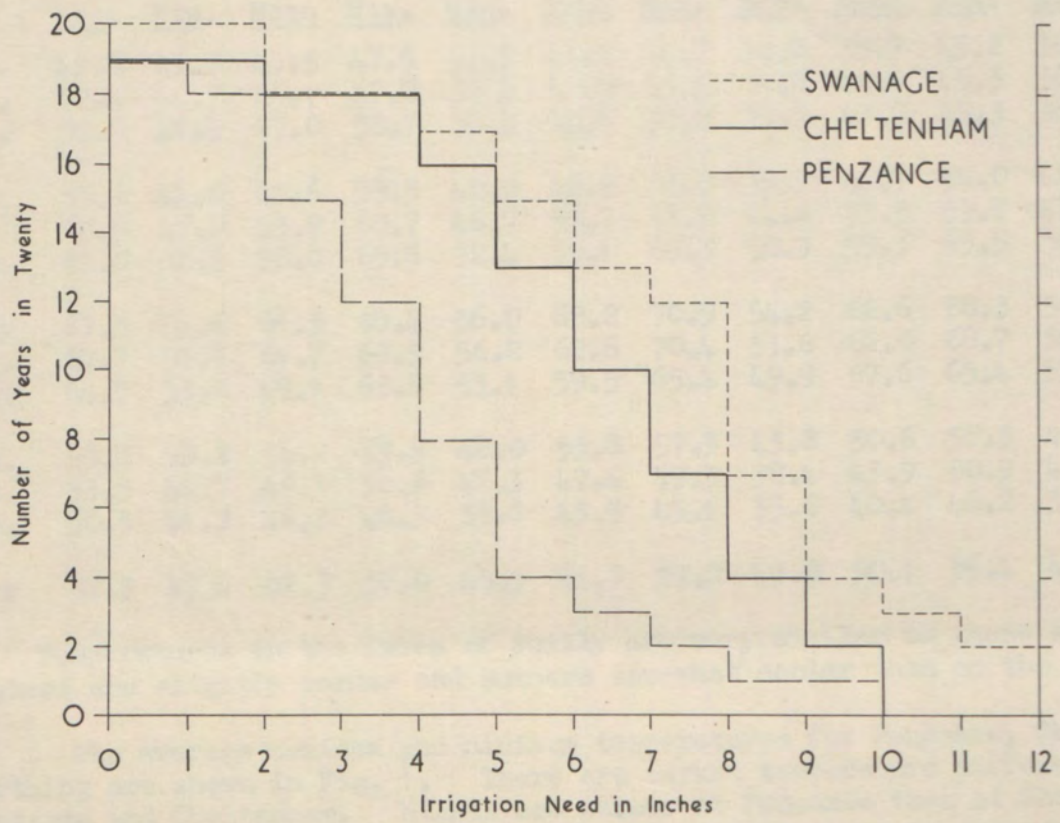
AVERAGE MONTHLY RAINFALL 1916–50



IRRIGATION NEED

1" SOIL MOISTURE DEFICIT



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